

NATIONAL BUREAU OF STANDARDS

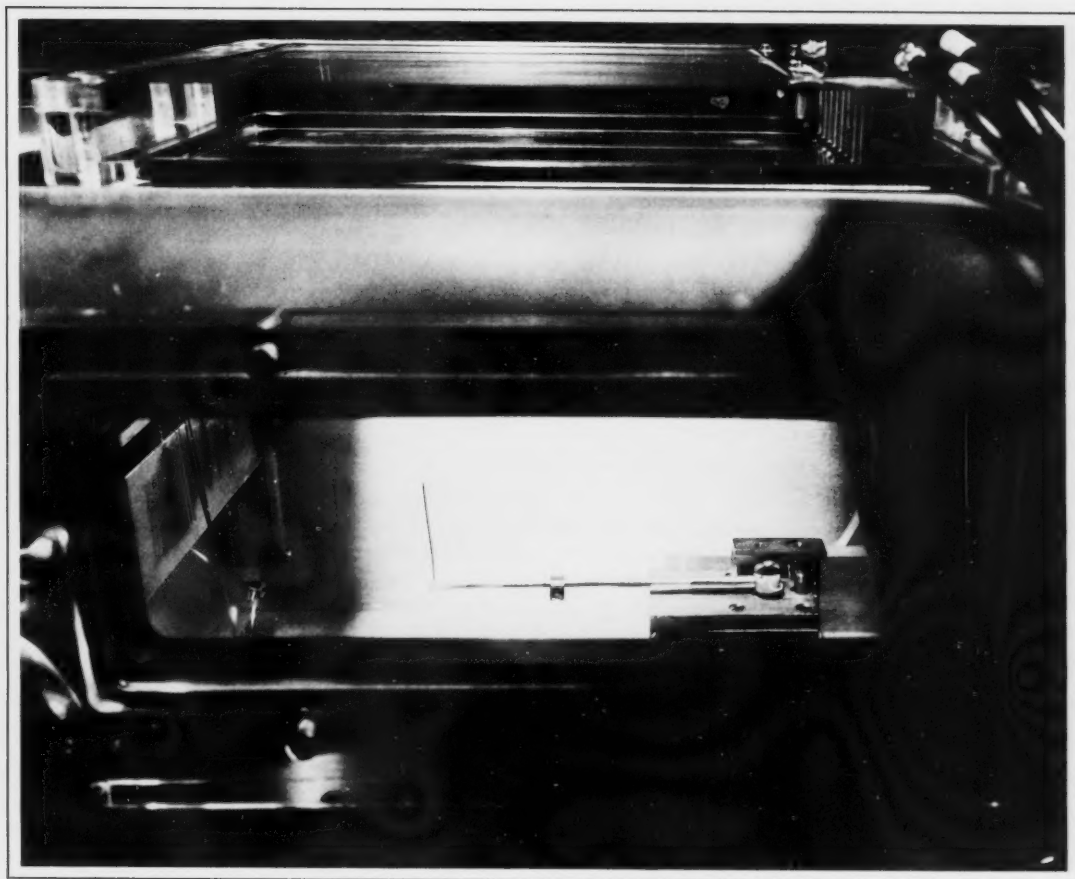
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COVER: Target chamber of the NBS isotope separator. This facility enables the Bureau to separate and study a wide range of radioactive and nonradioactive isotopes. (See page 239.)

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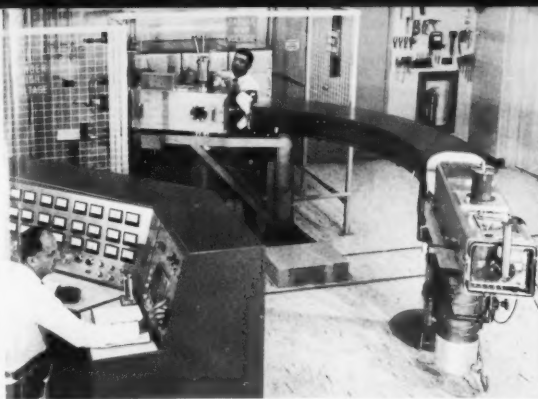
The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology
- Center for Radiation Research

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Left: The NBS electromagnetic isotope separator. Its ion source is to the left of the curved electromagnetic; its target chamber is at the near end. W. B. Mann, seated at the control console, tests the scanner oscilloscope. J. E. Harding connects vacuum hoses for degassing the spare ion source. Right: This spectrum of krypton, Kr-80 through Kr-86, was plated on aluminum foil. The unlabeled isotopes may be krypton hydrides.

ISOTOPE SEPARATOR LABORATORY

A new isotope separator laboratory at the NBS Center for Radiation Research in Gaithersburg, Md., now enables the Bureau to separate and study a wide range of isotopes, both radioactive and nonradioactive. Equipped with an electromagnetic isotope separator, the laboratory has already proved highly useful to NBS in the preparation of isotopically pure sources, the irradiation of various materials, in studies of nuclear structure, and ion implantation in semiconductors.

The isotope separator laboratory is being operated, under the direction of W. B. Mann, as a national facility in the Washington area. Scientists from other Government agencies, as well as industrial and academic laboratories, may arrange to use the isotope separator for experiments in their special fields of interest.

The laboratory building is adjacent to the Center's radiation physics laboratory. Besides the isotope separator room, the building houses two radiochemistry laboratories, two electronic equipment rooms, an office, and a mechanical equipment room containing a backing pump, a compressor for the refrigerated baffles of the diffusion pumps, and a water-cooling system.

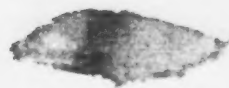
In this instrument isotopic separations are produced by the combined action of an electric and a magnetic field. The isotope separator consists of an ion source and extractor power

supply, an accelerator power supply capable of accelerating ions through a potential of up to 90 kilovolts, an electrostatic-lens chamber, a 90-degree-sector electromagnet of 150-centimeter radius, and a dispersion and target chamber in which deceleration of the ions to a few hundred volts is possible.

The instrument has the following features: It can develop continuous beam currents of more than 20 microamperes, sometimes as large as 100 microamperes. It has a mass dispersion sufficient to separate all known isotopes, a target chamber with facilities for controlling the temperature of the target, a wide range of accelerating potentials, a suitable collimating aperture and lens system for adjusting the shape of the beam, and means of measuring the ion current hitting the target.

The ion source material can vary considerably, from a gaseous substance to metallic oxides. In the latter case a typical operation consists of placing a crystalline or powdered oxide in a quartz tube, and usually passing carbon tetrachloride vapor over it, forming a chloride of the given metal. Some of the chloride as a vapor proceeds into the ion source and becomes ionized. A special extractor field draws out the initial ion beam, which then is accelerated toward a target. This ion beam is focused by an electrostatic-lens system into the field of the electromagnet that disperses the ions

continued



Kr⁸⁰



Kr⁸²



Kr⁸³



Kr⁸⁴



Kr⁸⁶

ISOTOPE *continued*

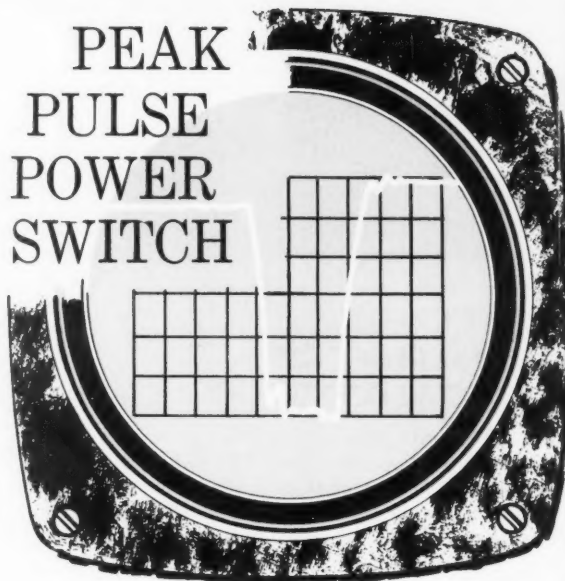
according to their charge and mass, the lighter ions being deflected the most. The dispersed ions of the isotope of interest are then collected by a target. It is interesting to note that the final energies of the ions arriving at the target also depend upon their state of ionization. For example, a doubly ionized atom accelerated through a 75-kV potential arrives at the target with kinetic energies of 150 keV.

The isotope separator has a great many uses, some of which have already been explored by NBS staff members or guest scientists. Nuclear orientation studies of thulium-170 implanted in iron foils have been made by NBS scientists D. D. Hoppes, A. T. Hirshfeld, and J. F. Twomey.¹ Other nuclear orientation studies have involved the isotopes barium-140 and praseodymium-142, also implanted in iron foils. Similarly, krypton-82 and 83 have been implanted in aluminum foil for studying Mössbauer effects. Damage effects on materials caused by isotopes have been the subject of another study performed by A. R. Landgrebe of NBS and M. Cefola of Fordham University. Research on semiconducting materials can also make effective use of the implantation process.

It is hoped to install a pneumatic tube system, which would connect the isotope separator laboratory's radiochemistry laboratories with the target rooms of the Bureau's 150 MeV linear accelerator in the adjacent radiation physics building. This would allow for rapid transmission of a target after it had been irradiated in the accelerator. The target then could be tested to determine the isotopic constituents of the products that have very short half-lives. The installation of a beta-ray spectrometer is also being planned, to provide for the spectroscopic investigation of the decay schemes of the radionuclides produced.

¹ Hoppes, D. D., Hirshfeld, A. T., and Twomey, J. F., Effective magnetic field at ¹⁷⁰Tm nuclei implanted in iron, *Bull. Am. Phys. Soc., Ser. II*, **13**, No. 1, 126 (1968).

PEAK PULSE POWER SWITCH



Pulse power at high frequencies (radiofrequencies) makes possible such systems as radar, aircraft navigational systems (TACAN), aircraft crash locators, orbiting satellite telemetry, and air traffic control. By and large, the principal users of these systems are the national defense agencies and the aerospace industry. To meet the needs of these and other users for improved accuracy in the measurement of peak-pulse power, the Bureau maintains a pulse-power measurement system and calibration service at its Boulder laboratories.

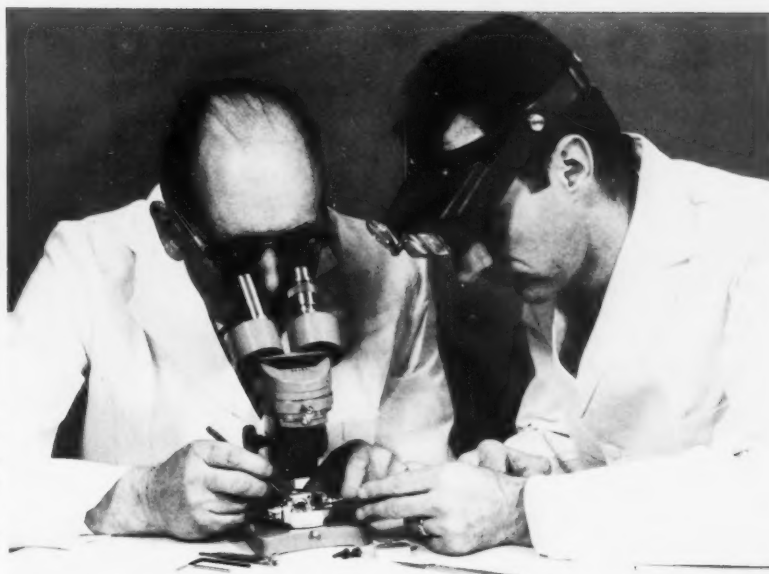
An important component in this measurement system is a fast-acting diode switch. Recently, A. R. Ondrejka and J. R. Benes of the NBS Radio Standards Engineering Division developed an improved switch that extends the frequency range of the NBS pulse-power standard up to 2.4 GHz from the previous 1.3 GHz level. The switch has a maximum VSWR (voltage standing wave ratio) of 1.10 in the frequency range of 0.1 to 2.4 GHz as compared to typical VSWR's of 1.5 to 2.0 GHz for other available switches. It has a switching time of less than 5 nanoseconds and can be used to calibrate rf power levels from 1 milliwatt up to 2 kilowatts.

Pulse Power Measurement

Measurements of peak-pulse power are made for a number of reasons, one of which is to determine if a pulse-power system is delivering the amount of power for which the system is designed. To make such measurements NBS uses the sampling-comparison method which is based on the well-established principle of comparing one quantity against a second whose value is known or can be measured with the desired degree of accuracy. Comparison is made



Above: An internal view of the new peak-pulse power switch with hand-fitted aluminum housing. The probe points to a shunt resistor that compensates for the series resistance of the switch diodes. Right: J. R. Benes (left) and A. R. Ondrejka assemble a precision peak-pulse power switch they recently developed.



between peak-pulse power at a given carrier frequency and continuous wave (cw) power at the same frequency.

The sampling-comparison method requires a fast SPDT diode switch having one output biased normally closed and a second output biased normally open. The diodes in the switch are arranged so that a negative pulse from a switching pulser reverses the open-closed conditions of the switch outputs. The pulser is synchronized with a main pulse generator that modulates the rf source. During the time the switching pulse is impressed upon the switch, the rf pulse power is switched from one output to another. By adjusting the width of the sampling pulse to a small fraction, typically one-tenth of the rf pulse width, a true time sample of the rf pulse power is fed to an average power detector.

A variable delay network allows the time sample to be taken anywhere along the rf pulse width; hence it may be taken at the peak of the pulse by simply varying the delay for maximum dc output from the average power detector. This output value is measured with a precision millivolt potentiometer and recorded. The switch is then connected to a source of cw power. While all parameters of the sampling pulse are kept fixed, the cw power is varied until the average power detector output is equal to the previously recorded value. Under these conditions the switch samples the cw power at the same rate and for the same time interval as for the pulse power.

The heart of the NBS pulse-power calibration system is the fast-acting, coaxial SPDT diode switch. A particular requirement of this switch is that it possesses a low VSWR, as close to a value of unity as is possible. A low VSWR signifies that the switch is accepting very nearly all

of the energy applied to it. Energy which is not accepted but reflected¹ instead, represents an uncertainty in energy measurement. The switch must also have a wide and a continuous frequency range to extend the measurement capability of the calibration system. It should also have a short sample time to secure a rectangular sample of the pulse to be measured. This rectangular sample is desired to assure complete sampling of the amplitude, good stability, and sufficient average power to the detector.

The new diode switch is of compact size measuring only 1 x 1 x 3 inches. The diodes, 6 in number, are miniature sized type 1N 4153, which are only 0.073 inch in diameter and 0.140 inch long. The diodes are series connected. The switch housing, developed and built by Benes, employs precision, hand-fitted aluminum parts. Because of its small size, the switch is assembled with the aid of a microscope.

The low VSWR is achieved by a strict dimensional control of the switch's mechanical components. The diode electrical parameters are compensated for by adjustable shunt capacitors and shunt resistors.

Use of the switch in the NBS pulse-power measurement system extends the frequency range of the NBS pulse-power standard upward to 2.4 GHz to include the new unified telemetering band at 2.2 to 2.3 GHz. The frequency range, starting at 0.1 GHz, is continuous.

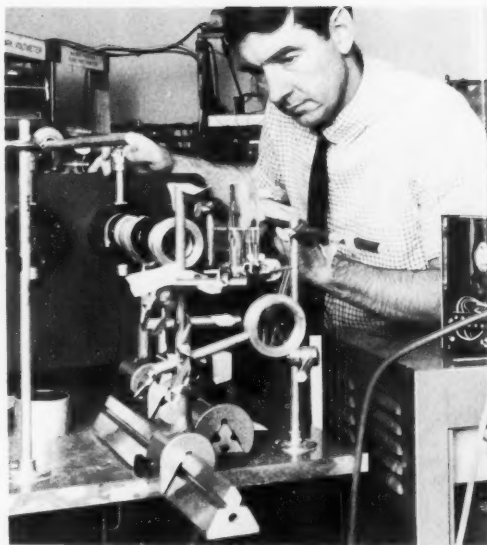
The switch represents the state-of-the-art in rf sampling switches. In its present form it is primarily suited for standards-laboratory applications¹ where pulse-power transfer standards are calibrated for eventual field use.

¹ ρ , the ratio of the incident voltage amplitude to the reflected voltage amplitude, is simply related to the VSWR: $\rho = (VSWR - 1)/(VSWR + 1)$.

LASER APPLIED TO MOLECULAR KINETICS STUDIES

Light Scattered in Liquid Reveals New Data

*Michael McClintock adjusts experimental apparatus
used to observe the Raman spectrum in benzene with
an argon laser.*



Spectral analysis has long been an important tool for obtaining data on the intrinsic properties of atoms and molecules. In 1928, the discovery of the Raman effect by the Indian physicist C. V. Raman made it possible to study molecular dynamics by analyzing the light scattered from transparent liquids, solids, or gases. The intensity of the Raman effect (which appears as extra lines in the spectrum of scattered light near each prominent line of the spectrum of incident light) is governed by the polarizability of the molecule. The Raman spectrum is faint (between 10^{-8} and 10^{-14} of the incident light intensity), and some of the most important regions of this spectrum are crowded within a few wave numbers of the exciting frequencies. Therefore, an incident light that is spectrally narrow enough to resolve the Raman spectrum is an absolute prerequisite for a detailed study of Raman scattering. Light from an argon laser meets this requirement.

Recently at Boulder, Colo., Michael McClintock of the NBS Institute for Basic Standards used an argon laser as a source to obtain and analyze the Raman and Rayleigh spectra in several transparent liquids.¹ (Rayleigh scattering may be viewed as a

special case of Raman scattering in which the incident light frequency is not changed upon scattering.) His mathematical evaluation of the experimental data related scattered light spectra to viscosity, to molecular rotation and vibration, and to certain molecular concentrations in mixtures of two unassociated liquids. Analysis of the Raman spectrum also provided new data on molecular coupling.

The experimental procedures used at NBS to obtain both the Rayleigh and the Raman spectra were nearly identical, except for minor adaptations of the apparatus to fit the specific needs of each case. In general, the beam from an argon ion laser was first passed through a dispersing prism to eliminate all but the 4880-angstrom radiation. The light was then fully polarized by passing it through a linear polarizer. A long-focal length lens focused the beam into a quartz scattering cell, which contained the liquid (benzene, carbon disulfide, or carbon tetrachloride). The scattered light was then examined from various angles by a spectrometer. Photomultiplier tubes served to increase the intensity of the spectral lines so that they could be recorded.

The rotational relaxation times of vibrationally excited molecules, derived from Raman lines, provided new information about the liquids. (Rotational relaxation time refers to the mean time for a molecule to become reoriented by collisions with its neighbors.) Relaxation times for vibrationally excited benzene molecules, for example, were found to be 5 to 10 times shorter than the relaxation times of ground-state molecules. This indicated that considerably less rotational coupling exists between molecules that are all in the ground state than exists between vibrationally excited molecules and molecules in the ground state.

Data on the rotational relaxation times for benzene, carbon disulfide, and carbon tetrachloride also helped to substantiate a newly developed theory of the molecular kinetics of liquids, based on the model of rotational Brownian motion.²

Seven different mixtures of benzene and carbon tetrachloride were investigated; the amount of benzene was varied from about 10 percent to 80 percent. Analysis of the spectral linewidth and intensity of portions of the Rayleigh spectrum led to the derivation of equations for the con-

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NBS STUDIES

LOSS OF PRESTRESS IN CONCRETE

Prestressed concrete* has advantages over conventional reinforced concrete that make it preferable for many applications. It is more resistant to cracking, for example, and can also be used in longer span lengths. Some properties of concrete thus treated, however, have not been fully explored. Chief among these is the loss of prestress due to shrinkage and creep upon aging.

With the tremendous amount of prestressed concrete being used every day, it is essential that its characteristics be known. To this end, P. H. Petersen and D. Watstein of the NBS Institute for Applied Technology recently made a study of the shrinkage and creep occurring in prestressed concrete as a function of aging and environmental conditions. Deformations under different conditions of humidity, ratio of prestress to strength, and ratio of cross-section area to surface area per unit length (mass ratio) were determined for time intervals up to 500 days.

In the NBS tests concrete specimens made with normal (Type I) and high early-strength (Type III) portland cement were used. Forty-nine sets of specimens were fabricated and tested. Each set consisted of a prestressed, symmetrically reinforced specimen and an otherwise identical comparison specimen without reinforcement. The unreinforced specimen served as controls to determine the shrinkage or swelling.

The reinforcement consisted of 0.1125-inch diameter steel spring wire. Depending on the size of the specimen, 4, 16, 48, or 64 wires were used.

All specimens were fabricated in the form of right prisms with square, hexagonal, or octagonal cross sections. Lengths ranged from 32 to 67 inches. The concrete consisted of cement, sand, and pea gravel in the proportions 1: 1.5: 2.0 by dry weight. All specimens were wet cured until the age at which the prestress force was transferred to the concrete.

The reinforcement wires were pretensioned at least a week in advance of casting concrete to eliminate effects of creep of the steel. An initial steel tensile stress of either 125 000 psi (8.6×10^6 N/m²) or 119 000 psi (8.2×10^6 N/m²) on each wire was recorded at the time the prestress was transferred to the concrete. The wires were thoroughly cleaned with solvent before casting the concrete to facilitate bonding throughout their length.

When the prisms reached the desired age of either 7 or 28 days, the prestress was transferred to the concrete by releasing the wires from the holding devices that were used for pretensioning the wires. Immediately before and after transferring the prestress strain to the concrete, gage readings were taken. The readings were continued at regular intervals up to an age of 500 days. Readings were taken on the nonstressed specimens each time they were made on the prestressed ones.

Upon release of prestress to the concrete, any change in gage length on the concrete was assumed to denote the same change in length in the steel. Thus, the residual total load still in the steel wires could be computed, and from this, the concrete compressive stress based on net area of concrete was determined.

Data on the specimens were divided into the two ages at which the prestress forces were transferred to the concrete (7 and 28 days). Creep, shrinkage or swelling, initial concrete prestress (allowing for elastic deformation only), and subsequent stress in the concrete at ages of 1, 10, 100, and 500 days (from the time of transfer of prestress) were obtained.

The NBS study showed that early shrinkage of nonstressed specimens exposed to 70 °F and 50 percent relative humidity was dependent upon the mass ratio. Small cross-sectional specimens exhibited more rapid shrinkage at an earlier age than the larger specimens, but the larger specimens appeared to approach the shrinkage values of smaller ones at ages of about 500 days.

Loss of prestress in the reinforced specimens varied linearly with the ratio of initial concrete prestress to initial strength, regardless of strength of concrete or age of release of prestress. There was little difference in the percentage of loss of prestress between specimens of normal portland cement and those made with high early-strength cement when storage conditions were the same.

Unit creep strain (creep strain at 500 days divided by initial concrete prestress) was found to be dependent upon moisture conditions during storage. Greater creep per psi of stress occurred at 50 percent relative humidity than at 100 percent relative humidity.

Unit creep strain at 500 days appeared to be almost independent of the prestress-strength ratio for specimens stored at 100 percent relative humidity. For specimens stored at 50 percent relative humidity, however, unit creep strain at 500 days appeared to decrease linearly with increasing prestress-strength ratios. The mass ratio had little significant effect on the unit creep strain at 500 days.

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*Prestressed concrete is reinforced concrete in which the reinforcement wires are tensioned before placing the concrete around them. When the concrete dries enough for a bond to form, the wires are released; this transfers the stress to the concrete.



NEWS

This column regularly reports significant developments in the program of the National Standard Reference Data System, which was established to make critically evaluated data in the physical sciences available to science and technology on a national basis. The System is administered and coordinated by the NBS Office of Standard Reference Data.

CODATA Meeting Held in Germany

The Third Annual Meeting of the Committee on Data for Science and Technology of the International Council of Scientific Unions was held in Frankfurt, Germany, June 28 and 29, 1968, in the offices of the Gmelin Institute.

NBS was represented by E. L. Brady, Chief of the Office of Standard Reference Data, who attended as an observer.

Committee membership is of three types: national members, Scientific Union members, and co-opted experts. The original national members were France, Japan, the Soviet Union, the United Kingdom, the United States, and West Germany. Canada joined recently and Italy will join soon. During the meeting the national members of Japan and the Soviet Union were elected to the Bureau of CODATA (the executive committee) and Guy Waddington, former Executive Director of the Secretariat for CODATA, was elected as a co-opted expert.

The Central Office of CODATA was transferred from the National Academy of Sciences in Washington, D.C., to the Institute for Documentation in Frankfurt on July 1, 1968; at the same time, Executive-directorship was transferred from Guy Waddington to Christoph Schäfer. The new address is ICSU-CODATA, Westendstrasse 19, 6 Frankfurt/Main, Germany.

Among the principal activities of the CODATA office have been the preparation for the first international CODATA Conference on Numerical Data held at the Evangelische Akademie, Arnoldshain (near Frankfurt), and the gathering and editing of information for a compendium of data compilation projects currently in progress throughout the world.

At the Frankfurt meeting, reports were presented on the activities of the task groups for computer usage, key values

for thermodynamics, and fundamental constants. Principal activity of the task group on computer usage has been a survey of machine techniques used in various data centers throughout the world. The task group on key values for thermodynamics has decided on the properties and substances with which it will deal and has considered a preliminary set of 17 key values prepared by members from the U.S. and U.S.S.R.

CODATA Conference on Numerical Data

To promote the objective of serving as a channel of communications, CODATA organized a symposium entitled the *First International CODATA Conference on the Generation, Collection, Evaluation, and Dissemination of Numerical Data for Science and Technology*. The conference was held at the Evangelische Akademie in the Taunus Mountains. Almost 100 attended, representing 13 countries and one international organization—the International Atomic Energy Agency. The participants were data evaluators, program managers, documentalists, government officials, and CODATA representatives from all member countries.

The program featured discussions of the major national programs, operation of a number of specific projects (Landolt-Börnstein Tables, IUPAC Center on Thermodynamic Properties of Fluids, Thermophysical Properties Research Center, Neutron Cross Section Data Center), common problems of compilers working in related fields (thermodynamicists, infrared spectra), the use of computers in data centers, and the future role of CODATA itself. Some of the reported data and related activities of the attending countries were as follows:

(a) *Soviet Union*. Five representatives of the Soviet Union attended the conference, and reviewed data activities in their organizations. The senior member of the U.S.S.R. group was M. A. Styrikovich, a Deputy Chairman of the Academy of Sciences and Chairman of the National Committee for CODATA. A second member of the group was the Deputy Director of the Soviet State System of Standard and Reference Data (GSSSD). The GSSSD is a responsibility of the State Committee on Standards, a

body with organizational status equivalent to that of the Academy of Sciences. Three others represented the Institute for High Temperature in Moscow.

(b) *Germany.* The Physikalisch-Technische Bundesanstalt (PTB) in Germany (approximately the equivalent of NBS) has embarked upon a study of data compilation activities and establishment of information centers.

(c) *France.* The government of France has recently established a National Bureau of Metrology, with functions similar to those of the National Bureau of Standards. Previously these functions had been scattered through four different Ministries. The new Bureau does not intend to construct new physical facilities but will coordinate and integrate the various scattered activities.

During the meeting, panels on infrared spectroscopy and chemical thermodynamics made progress in planning better coordination of future efforts in these fields. Other panels achieved some results on defining terms and on indexing. The panel on definitions of terms considered the connotations of the widely used term "standard," as in Standard Reference Data. For example, in the U.S.S.R. it connotes a legal standard or specification; in other countries it may imply recommendation by an international body or by a national standardizing laboratory; still others would use it to refer to any collection of evaluated data.

In a final session, CODATA received many suggestions for future work. Noteworthy was a proposal from V. N. Kondratiev of the U.S.S.R. that evaluation and compilation of data for chemical kinetics be started on an international basis. A closing recommendation was that a Second CODATA Conference on Numerical Data be held in 1970 somewhere in Europe.

NBS Alloy Data Center

The NBS Alloy Data Center, one of the data centers in the National Standard Reference Data System, has two primary functions. One is to maintain an awareness and to stimulate communication and exchange of information between (already existing) data centers in the metals and alloy fields. The other is to collect and evaluate data in those fields where special competence exists within the NBS Alloy Physics Section. The Alloy Data Center is part of the Alloy Physics Section within the Metallurgy Division of the Bureau. Areas in which the Section is carrying out programs of active research are: nuclear magnetic resonance (NMR), ferromagnetic nuclear resonance, soft x-ray spectroscopy, Mössbauer effect, low temperature measurements of specific heat and susceptibility, and other magnetic properties.

At the Center documents have been compiled for NMR in metals and alloys. All documentation on experimental Knight shift results is complete and up to date. The Knight shifts are now being evaluated for publication; other NMR parameters may be evaluated at a later date. An annotated bibliography on soft x-ray spectroscopy was

prepared in the Alloy Physics Section before the Center was formed. This compilation is being kept current by the Center and the evaluation of the soft x-ray spectra will be underway shortly.

A single bibliographic system has been designed to automate the Center's document file. NBS Technical Note 464, *The NBS Alloy Data Center*¹ (\$1.25), describes how the system may be used directly by others who intend to maintain files of documents in this technical area. Although the system was designed to handle specific properties of certain materials of interest to the Center, it may be used effectively to document papers covering other properties of these materials. For the system to handle these other properties, a modified thesaurus is used that allows the structure and most of the coding of the system, as well as the computer programs, to remain unaltered. Other data groups who use the system for the storage and retrieval of their own documents may have the Center's files added to their magnetic tapes.

In the system, the classification of properties is strongly oriented toward the storage and retrieval of papers dealing with experimental results or papers bearing directly on experimental results. The automated bibliographic system also has built into it a method for bringing together papers in related fields. This is an important feature for data evaluators in that it facilitates a check on the internal consistency between tables of different properties.

ICSU-UNESCO Panel Meeting on Scientific Information

A joint ICSU-UNESCO study on the feasibility of an international science information system has been underway for approximately two years. At a meeting of the Working Group in Paris, December 1967, a number of subpanels were established to study special aspects of the problem. One of these was on the subject of evaluation, compression, and organization of scientific information, under the leadership of H. Kaiser, Director of the Institute for Spektrochemie and Angewandte Spektroskopie in Dortmund, Germany. E. L. Brady of the National Bureau of Standards is a member of this subpanel. The subpanel met at the Royal Society's headquarters in London, U.K., on July 8, 1968, and approved a report on Evaluation, Compression, and Organization of Scientific Information. The report has been submitted to the ICSU-UNESCO Working Group and has been accepted as a working document.

Charlotte Moore Sitterly Serves as Consultant

On September 30, 1968, Charlotte Moore Sitterly, Director of the Atomic Energy Levels Data Center, retired after 23 years of distinguished service at the National Bureau of Standards. She had served as leader of the Atomic Energy Level project in the Atomic Physics Division for 22 years. William C. Martin of the NBS Atomic Physics Division, with the assistance of Lucy Hagan, took over the

work of the Center. Dr. Sitterly, however, will continue her association with NBS and the NSRDS, receiving a special appointment as Consultant to the Office of Standard Reference Data. (Dr. Sitterly's technical publications appear under the name of Charlotte E. Moore.) Dr. Sitterly has been working on a number of tables of atomic spectra that have yet to be completed. One of her tasks as a consultant will be to complete these tables. In addition, she will prepare for publication manuscripts on the spectra of Yb I, Hf I, Mo I, and Ta I; a manuscript on the temperature classification of Dy; and an updated bibliography of the atomic spectra, continuing the lists published in NBS Circular 467.

A symposium and reception were held at NBS in honor of Dr. Sitterly on October 4, 1968. Principal addresses were given by Jesse Greenstein of the California Institute of Technology, A. G. Shenstone of Princeton University, and Richard Tousey of the U.S. Naval Research Laboratory.

NSRDS Publications To Use SI Units

In accordance with NBS policy,² the Office of Standard Reference Data has recommended to all data centers and projects associated with the NSRDS that the International System of Units be used in all publications prepared for the NSRDS.

U.S.-U.S.S.R. Cooperation in Data Compilation

Donald D. Wagman, Chief of the NBS Chemical Thermodynamics Data Center, visited the U.S.S.R. June 17-30, 1968, as a member of the CODATA Task Group on Selection of Key Values of Chemical Thermodynamic Properties. Included in Mr. Wagman's itinerary were visits to the Thermochemical Laboratory of Moscow State University, the All-Union Institute of Scientific and Technical Information (VINITI), and the Mendelev Institute of Metrology in Leningrad.

Discussions were held at laboratories of the Institute of High Temperature and at Moscow State University. V. P. Vassiliev of the Institute of Chemical Technology at Ivanovo, who has been correlating data on heats of dilution, was also present for some of the discussions. S. M. Skuratov, Director of the Thermochemical Laboratory and one of Russia's leading calorimetrists, expressed the hope that his and the NBS group could soon pool efforts and thus expedite the entire program of thermodynamic data evaluation.

As a result of the discussions, the Soviet group agreed to accept the values recommended by NBS for certain carbon compounds. The agreement will make the tables prepared by the two groups more compatible and mutually consistent. In addition, it was agreed to establish a procedure for mutual review of selections of values for other important substances. This procedure will also

be used in establishing key values of thermodynamic data to be proposed to the CODATA Task Group.

While in Moscow, Mr. Wagman visited several of the research divisions of the Institute of High Temperature. This Institute, under the direction of A. E. Sheindlin, was created by bringing together a number of research groups previously located in other Institutes. Its general programs are carried out in six main divisions: liquid metals and gases, high temperature solids, molecular physical chemistry, magnetohydrodynamics, plasma physics, and mechanical properties and fabrication of refractories.

These divisions frequently serve as research groups for larger institutes engaged in practical applications of magnetohydrodynamics, high energy chemistry, nuclear reactor materials, etc. In addition, the divisions carry out extensive research programs of their own.

These research programs appear to focus on the preparation and publication of complete reference works on classes of substances. The Division of Liquid Metals and Gases, under E. E. Shpilrain, has set itself the task of preparing a compendium on the alkali metals. To fulfill this task, the experimental programs of the division provide needed data on thermal conductivity, electrical conductivity, viscosity, and density as a function of temperature for the alkali metals and their binary systems.

Similarly, the experimental programs of the Molecular Physical Chemistry Division, under Lev Gurvich, provide the experimental data in spectroscopy and molecular structure necessary to guide them in their program of reference data on high energy compounds, heavy metal oxides, halides, carbides and nitrides, and alkaline earth compounds. Development and use of empirical correlation schemes also appear to be an integral part of their effort. Thus, the data compilation and evaluation efforts serve as foundations for the experimental programs of the research groups.

Quantitative Electrical Letter Symbols

USA Standard Y10.5-1968, *Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering*, has been issued by the USA Standards Institute and by the American Society of Mechanical Engineers, the sponsors of this standard. This USA standard joins nearly 3000 other standards that have been approved as American Standards by the American Standards Association (ASA). On August 24, 1966, the ASA was reconstituted as the United States of America Standards Institute. Standards approved as American Standards are now designated USA Standards. The Office of Standard Reference Data is encouraging projects and data centers to follow USAS Y10.5-1968.

¹ Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

² See NBS Interprets Policy on SI Units, NBS Tech News Bull. 52, No. 6, 121-124 (June 1968).

CRYOGENIC FLOW RESEARCH FACILITY ESTABLISHED AT NBS

A new Cryogenic Flow Research Facility, sponsored jointly by the National Bureau of Standards and the Compressed Gas Association, has recently been established at the Boulder (Colo.) laboratories of the NBS Institute for Basic Standards. The design, construction, and operational planning for the facility have been under the direction of D. B. Mann, J. W. Dean, and J. A. Brennan of NBS.

This experimental facility, unique to cryogenics, will allow the study of fluid metering and fluid metering practices under controlled conditions, and over a wide range of temperatures and pressures. It is expected that from these studies a uniform methodology for flow measurement of cryogenic fluids can be defined and new flow measurement techniques evaluated.

Impetus for such a facility came from a growing awareness by those working in the cryogenic field that direct application of the classical methods of fluid metering to cryogenics was failing to give the precision and accuracy required, mainly because of a lack of definition as to how meters should be installed and operated. Also, recent interest by industrial and regulatory agencies, in the area of commercial transfer measurement of cryogenic fluids, has pointed up the lack of quality research in this area.

Through the use of the test facility, NBS will carry out an extensive cryogenic fluid metering program oriented towards satisfying the commercial transfer needs. Thus, the focus will be on investigating problems arising from the quantity-type, moderate-flow rate metering of cryogenic fluids associated with commercial transfer. The program is expected to be concentrated in the following three areas: (1) The study of the performance of existing classical meters under well-defined reproducible conditions; (2) the development of recommended practices for the most effective transfer of cryogenic fluids of interest in commerce; and (3) the investigation of new commercial transfer metering devices.

The facility consists of a pumped cryogenic flow loop, designed to give continuous, steady-state operation. The working fluid, either liquid nitrogen or liquid argon, is pumped out of a storage or catch tank into a heat exchanger, where the pump and heat energy are removed, and then back into the catch tank. This provides for thermal equilibrium and the operation of a closed system without liquid loss.

Flow rates will range from 20 to 200 gallons per minute, which is the rate area of prime interest to industry. Pressures and temperatures may be varied within the system from 63 K, 94 mm Hg (1.25×10^4 N/m²) to 115 K, 275 psia (1.9×10^6 N/m²), by a combination of subcooler operation and nitrogen or helium gas pressurization.

The facility has the capability, with some modification, for the study of combined states such as liquid-vapor and liquid-solid. This was deemed necessary, since cryogenic fluids are nearly always boiling, two-phase mixtures, and because there is potential for no-loss storage by using liquid-solid mixtures (slush).

Although the facility is basically designed for flow research, a sophisticated calibration system is necessary to indicate meter performance. Thus, a dynamic gravimetric calibration technique is used to determine the fluid-mass flow rate or totalized flow. Thermophysical property data are being used, initially, to convert to volume flow rates.

The NBS Cryogenic Flow Research Facility will benefit the compressed gas industry and users by providing them with a common ground of recommended practices for the commercial transfer of important cryogenic fluids. It will also provide regulatory agencies a common place for type testing of cryogenic fluid metering devices. In addition, the facility will be of benefit to the entire cryogenics field by providing a better understanding of cryogenic fluid flow for the more efficient and economical operation of all types of cryogenic processes.

PRESTRESS *continued*

It was also found that wires 0.1125 inch in diameter, tensioned to 125 000 psi (8.6×10^8 N/m²) initial prestress, required an embedment for anchorage of less than 10 inches in length when used in good quality normal portland-cement concrete with an age of release of pre-

stress as early as 7 days. This was also true when used in high early-strength cement concrete with transfer as early as 3 days. The required length of embedment appeared to be independent of cure of concrete (wet or dry).

¹ For complete details, see Petersen, P. H., and Watstein, D., *Shrinkage and Creep in Prestressed Concrete*, NBS Bldg. Sci. Series 13 (Feb. 1968). For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 15 cents.

LARGE NEGATIVE ION OFFERS KEY TO IONOSPHERE



A pentatomic negative ion, thought to be the most complex negative ion ever isolated with sufficient resolution for unambiguous identification, has been investigated at the National Bureau of Standards. This ion, known as hydroxyl monohydrate (H_5O_2^-), has been shown to have the response to light that may characterize certain negative ions in the ionosphere, the layer of electrically charged particles in the earth's upper atmosphere. Thus it may be an ion for which scientists have been searching for the past 15 years. The ion's energy characteristics were found in photodetachment analysis studies conducted by Bruce Steiner and Stephen Golub of the NBS Institute for Basic Standards with support from Project DEFENDER (U.S. Department of Defense).

One of the interesting properties of the ionosphere is observed during polar-cap absorption events—periods sometimes lasting several days during which the absorption of radio waves increases in the polar regions. At this time there is a daily increase in ion concentration at sunset in the ionosphere's lowest (or D) region, and a corresponding decrease in ion concentration at sunrise. Because the D region acts as a reflectance barrier for electromagnetic waves such as radio and radar, the change in ion concentration causes noticeable changes in the propagation of these waves. These effects may result from the presence of ions with photodetachment energies equal to the amount of energy they absorb from solar radiation during the daylight hours. Thus,

in daytime the ions would lose electrons by photodetachment and become electrically neutral. Then, during the hours of darkness the electrons freed during the day would re-attach themselves to the neutral molecules in the ionosphere and again form negative ions. Scientists have been trying for many years to determine the identity of the negative ions responsible for these effects and to determine their true photodetachment energies.

Photodetachment energies of several negative ions have been determined, including such ions as O^- , O_2^- , OH^- , I^- , and SH^- ; ¹⁻⁴ however, none of these has a photodetachment energy comparable to the solar radiation energy required. More recently NBS scientists have completed equipment which enables them to investigate larger negative ions (5 atoms instead of 1 or 2 atoms). Experiments show that the five-atom ion, H_5O_2^- , possesses the necessary photodetachment energy for it to be considered an important ion in the ionosphere.

An important factor in the identification of this ion was the use of a double-focusing mass analyzer that focuses a narrow beam of ions for study, thus making possible much higher resolution and greater sensitivity. Besides the mass analyzer, the apparatus, which was designed with the assistance of Nikita Wells of NBS, consists of an ion source, a lens that focuses the mass-analyzed beam into the collision chamber, and a monochromatic light source.

In the collision chamber the ion beam interacts with the monochro-

matic light at various wavelengths selected by a special monochromator. During the collision the ions absorb photons and emit electrons that are focused into an electron multiplier above the collision chamber. Data recorded during the collision process include the photon wavelength and the variation of electron multiplier current with changes in wavelength. The shape of the curve above the threshold or "onset" is also of importance in giving a full analysis of the detachment process.

Photodetachment studies of other complex negative ions are being planned. A test stand to develop better ion sources has evolved from past experiments and is under concentrated study by NBS scientist Robert M. Mills. Parameters such as ion beam current (and voltage) as a function of beam intensity are being investigated, as are variations in chamber location for extracting the beam.

The main objective of the development program is to determine a set of parameters that satisfy requirements for a universal negative ion source. Such a source must produce any desired ion with as high a beam intensity as possible. This project should enable larger and more complex negative ions to be readily produced for study.

¹ Bates, D. R., and Massey, H. S. W., The negative ion concentration in the lower ionosphere, *J. Atmos. Terr. Phys.* 2, 1-13 (1951).

² Branscomb, L. M., Photodetachment cross section, electron affinity, and structure of the negative hydroxyl ion, *Phys. Rev.* 148, No. 1, 11-18 (Aug. 1966).

³ Steiner, B., The cross section for the photodetachment of electrons from I^- , *Phys. Rev.* 173, No. 1, 136 (Sept. 1968).

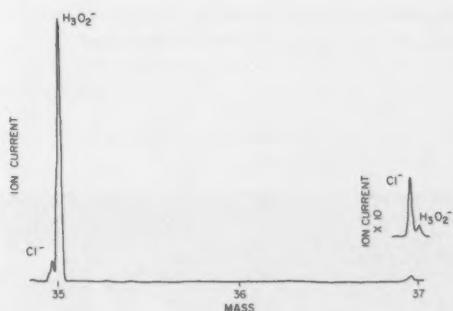
⁴ Steiner, B., The photodetachment of electrons from SH^- , to be published.

Bruce Steiner adjusts the ion beam indicator of the high resolution photo detachment apparatus.

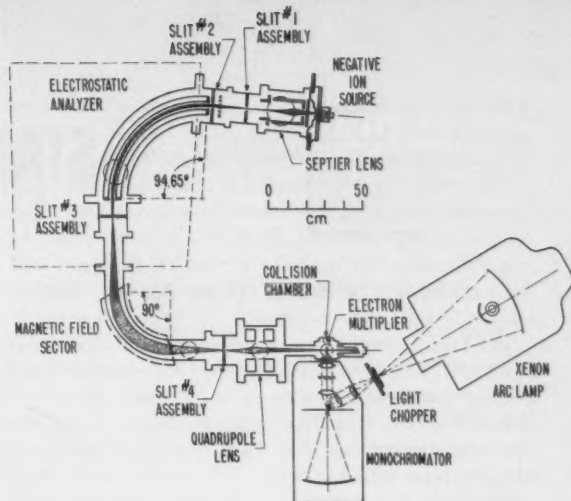
Schematic of the NBS double-focusing mass analyzer for determining the photodetachment characteristics of H_2O_2^- ions. High resolution and sensitivity was provided by the electrostatic analyzer and its assembly (in dashed block—upper left).



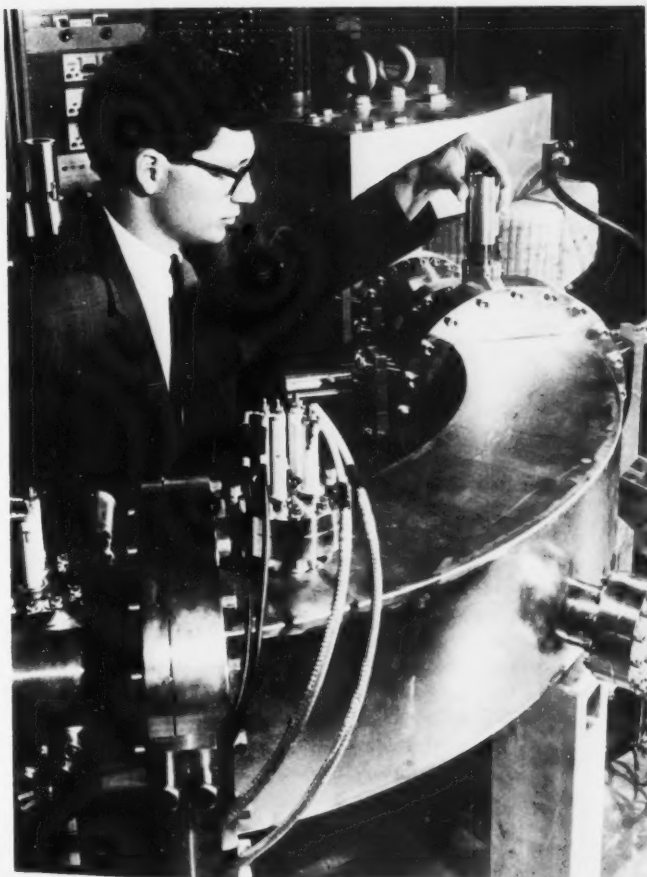
A test stand to develop a universal negative ion source has evolved from NBS photodetachment experiments. In the test chamber such variables as changes in current, voltage, pressure conditions, and location of beam extraction are studied. Robert M. Mills plots new data.



Ion current as a function of atomic mass for a hydroxyl monohydrate negative ion beam.



Stephen Golub adjusts the height of the exit slit of the analyzer. An electrostatic analyzer in combination with an electromagnet increases the energy and mass resolution of the negative ion beam.





STANDARDS AND CALIBRATION

STANDARDIZATION OF 3.5-mm COAXIAL LINE

The Joint Industry Research Committee on Standardization of Miniature Precision Coaxial Connectors has recommended the standardization of the 3.5-mm, 50-ohm, air-dielectric coaxial line. This recommendation resulted from the Committee's June 1968 meeting held at the Bureau's laboratories in Boulder, Colo.

The Joint Committee is composed of representatives from industry and government. It is concerned with improving the performance of miniature electronic coaxial connectors, which are extensively used in aerospace and electronic instrumentation applications. The Committee is also concerned with reducing the wide variety of non-interchangeable coaxial connectors now in use due to a lack of standardization.

At previous Committee meetings it was determined that two sizes of standardized miniature air-dielectric lines were necessary for precision electronic measurements in coaxial systems operating at frequencies up to 40 GHz.

The recommended 3.5-mm size will fit in well with the present IEEE standardized 7-mm and 14-mm line sizes. A smaller bore (less than 3.5-mm) line size will be recommended by the Committee in the near future when more data are available concerning the performance of miniature precision coaxial connectors.

The Committee is now working to develop precision connectors for the recommended 3.5-mm, 50-ohm, coaxial line. These connectors are to have no bead resonances at frequencies below 28 GHz and they will be recommended for use in systems operating at frequencies ranging from dc to 26.5 GHz. The 3.5-mm coaxial line can be used at frequencies up to 36 GHz; however, at such higher frequencies the beaded connectors can generate undesirable modes of propagation. This multimoding restricts the upper frequency limit of the connectors.

The recommendations approved by the Committee will form the basis of a voluntary standard to be developed under the Product Standards procedures issued by the Department of Commerce. The Bureau's Office of Engineering Standards Services will cooperate with the Committee in the development of the standard or standards that result from the Committee's activities in this area.

The Joint Committee is chaired by Andrew Alford, Alford Manufacturing Company. It meets several times each year and because its deliberations and recommendations can affect coaxial line and connector design standards, Committee activities are of considerable interest to electronic equipment manufacturers and users.

NBS participation in the activities of this important Committee is an example of service to industry and government by NBS.

10-KILOHM STANDARD RESISTORS

During the past several years there has been a growing need for increased accuracy in the measurement of resistance at the kilohm level. This need has been felt especially by the electronics industry, the military services, and the industrial standards laboratories.

To help provide the required accuracy, the NBS Institute for Basic Standards is now reporting calibration results for certain new-type 10-kilohm standard resistors to 0.1 ppm.¹ In the new calibration service, the total uncertainty for the measurement process is 0.0001 percent based on an estimated 3-sigma limit for random errors. This is a sevenfold improvement in measurement uncertainty compared with the service offered on older-type 10-kilohm units, and is equal to the present uncertainty given in reports of calibration for Thomas-type 1-ohm standards.

The recent commercial appearance of several improved types of 10-kilohm standard resistors having low temperature coefficients and low apparent time constants has warranted this additional service. The new 10-kilohm calibration service is not designed to replace that currently available to owners of Thomas-type 1-ohm standards, but rather to supplement this service by providing an additional high-accuracy reference point in the resistance spectrum. There is no change in the accuracy statement applicable to the older-type 10-kilohm standards.

Laboratories now employing some form of "bootstrap" technique in calibrating their various resistance standards from a one-ohm reference unit may find the new 10-kilohm standards quite useful in the process, especially when there is need to go to very high values on the re-

E. F. Gard (right) and T. E. Wells calibrate a new-type 10-kilohm resistor (at Mr. Gard's right elbow).



distance scale. In addition, the 10-kilohm level is of great importance because modern methods for the absolute measurement of resistance, starting from computable capacitors, assign values in absolute measure to standard resistors at this point in the scale of resistance values.

Data showing the accuracies now available at NBS for calibration of resistors are given in Table 1. Note that the uncertainty of measurement in the new calibration service (10 000-ohm entry) is equivalent to that for 1-ohm measurements, offering a convenient point to begin a boot-strap operation to higher values.

Because of the considerable amount of work required in calibrating 10-kilohm standards in terms of the unit maintained at the 1-ohm level, the new service will be available only at periodic intervals. Clients interested in this service should make a written request to:

Chester Peterson, Chief
Resistance and Reactance Section
Rm. B146, Metrology Bldg.
National Bureau of Standards
Washington, D.C. 20234

Requests will be acknowledged as received, and at suitable intervals of time (3 to 6 months) a measurement date will be announced. All owners will then be notified to submit their standards.

TABLE 1. *Accuracies currently reported by NBS for standard resistors (wire-wound type)*

| Nominal resistance | Nearest ppm to which reported values are rounded off | Measurement uncertainty |
|--------------------|--|-------------------------|
| <i>Ohms</i> | | <i>ppm</i> |
| 1 000 000. | 1. | 15. |
| 100 000. | 1. | 10. |
| 10 000. | 1. | 7. |
| New-type 10 000. * | 0.1 | 1. |
| only | | |
| 1000. | 1. | 5. |
| 100. | 1. | 4. |
| 10. * | 1. | 4. |
| 1. * | 1. | 3. |
| Thomas-type 1. * | 0.1 | 1. |
| only | | |
| 0.1 * | 1. | 5. |
| 0.01 * | 1. | 7. |
| 0.001 * | 1. | 12. |
| 0.0001 * | 1. | 20. |

*Four-terminal measurement.

COAXIAL NOISE GENERATORS

A service for the calibration of coaxial noise generators at 3 MHz has been announced by the Radio Standards Engineering Division (Boulder, Colo.) of the NBS Institute for Basic Standards. This service, which is the first

to be offered for noise temperature measurements of noise sources that operate in coaxial systems at high frequencies (nominally from 30 kHz to 1 GHz and above, for coaxial systems), will help industry and scientific laboratories to meet pressing needs for precise measurements of noise power spectral density. It augments a similar service that has been available for rectangular waveguide systems (WR62, WR90) in the microwave region ^{2,3} (nominally from 1 GHz to 40 GHz and above, for rectangular waveguide systems).

The quantity that is measured in this new service is the noise temperature ⁴ of random noise generators. The calibration is performed within a 9 kHz bandwidth centered at 3 MHz. Measurement capabilities are in the range of 75 kelvins (K) to 30 000 kelvins.⁵ Typical noise generators that will be calibrated under this service are thermal noise generators, shot noise generators (temperature-limited diodes and semiconductor diodes, and certain other types of generators using vacuum tubes, gas-discharge tubes, or semiconductors that produce thermal-like noise voltages in the frequency and power range specified).

Random noise generators are widely used in the measurement of the noise figure of radio receivers and amplifiers. Also, in certain critical applications, such as are found in the fields of radio astronomy and of deep-space probing by satellites, precision noise generators are used to calibrate the system noise temperature to assure maximum range and accuracy. To meet the demands arising from these activities, NBS scientists have worked for several years on a new technique ⁶ for the precise measurement of noise power spectral density. This technique uses a correlation scheme ⁷ whereby the power from the noise generator under calibration is compared with the power from a very stable and accurately controllable sinusoidal signal generator. Two very stable and accurately known random noise generators, built at NBS for this service, are used to calibrate the measurement system. One of these generators also serves as the reference standard for calibrating the noise generator under calibration.

An elementary explanation of the measurement technique is as follows. The power from the noise generator under calibration is compared with that from a stable CW generator by adjusting the CW generator power level to produce a null output voltage from the measurement system. Power from a reference standard noise generator is then compared with the power from the CW generator in like manner. The noise temperature of the generator under calibration is computed by the system equation,⁸ using the known noise temperature of the reference standard generator, the known relative change in the CW power level, and the empirically determined system parameters.

The measurement apparatus used in this new calibration service is similar to that described previously.⁸ Certain operational improvements have been made in the

STANDARDS AND CALIBRATION *continued*

present apparatus, but the overall features are the same.

The two reference standard noise generators are thermal noise generators consisting of passive electrical components immersed in temperature-controlled baths. One noise generator uses a bath of liquid nitrogen which is free to boil at a temperature (about 76 K) determined principally by the ambient atmospheric pressure. The other noise generator uses a bath of silicone oil that is heated to any selected temperature within the range of approximately 325 to 575 K. Both generators have an adjustable source impedance that permits setting the impedance of the reference standard to be the same as that of the noise generator under calibration. This minimizes the measurement error produced by the VSWR of the calibrated noise generator.

With the present apparatus, the uncertainty in the calibrated value of noise temperature is approximately 1 percent of the noise temperature. To realize this degree of accuracy, however, the generator under calibration must have a noise temperature instability no greater than approximately 0.25 percent per hour, and a source impedance instability no greater than 0.04 ohm per hour.

A noise generator submitted for calibration under this service must be either of coaxial design, or have a shielded enclosure with a coaxial fitting. The output connector should be coaxial, preferably a type N connector or one of the several types of precision connectors. If the output connector is not coaxial, it must be adaptable to coaxial configuration by use of a suitable adaptor.

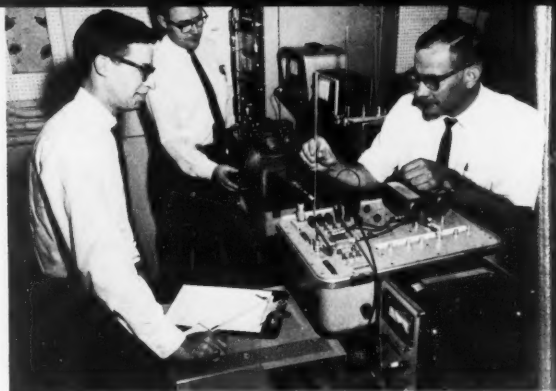
The source impedance of the noise generator should be within the range of $50 \pm 5 + j(0 \pm 5)$ ohms. This corresponds to a maximum VSWR of approximately 1.16:1.

For noise generators whose noise temperature exceeds 30 000 K, a suitable attenuator must be supplied with the generator to lower the temperature to within the operating range of the calibration service.

It is anticipated that a calibration service, similar to the one described, will be available at 30 MHz sometime during 1968. Work is in progress that will lead to a similar service at 1 GHz. Calibration services at other selected frequencies will be made available in accordance with demand.

GEOALERT CODE MODIFIED

Slight modifications⁹ have been made in the new GEOALERT coding system instituted January 1, 1968,¹⁰ for broadcasts by National Bureau of Standards radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii). The modified code was put in use on October 1, 1968. The new system makes possible the dissemination of larger quantities of information resulting from improved techniques in observation and prediction of solar and geophysical events. The modification to the new system clarifies five of the code symbols concerning strato-



Gerald Arthur (center) operates the new radio-noise standard for NASA Goddard Space Flight Center representatives Joseph K. Alexander (left) and James E. Guthrie. Although NASA has its own standard noise source, it must be calibrated against the NBS basic standard.

spheric warming observations. All previous codes are superseded.

GEOALERT messages are issued daily by the World Warning Agency of the International Ursigram and World Days Service (IUWDS) and are broadcast as a very slow sequence of International Morse Code symbols from stations WWV and WWVH on each of the standard radio carrier frequencies. The coded message alerts experimenters and researchers in radio, geophysical, and solar sciences to outstanding solar or geophysical events that are expected to occur that day or which began in the preceding 24-hour period.

Forecasts are made each day at 0400 UT (Universal Time) by the World Warning Agency at the Environmental Science Services Administration, Boulder, Colo. GEOALERT's for a given day are first broadcast at 0418 UT on station WWV, then at 0448 UT on station WWVH. These broadcasts are repeated at hourly intervals until the new alert is issued. (In case of delay in receipt of the daily message, WWV or WWVH will be silent at 18 or 48 minutes after the hour until the new message is received.)

Each message begins with the letters GEO in Morse Code, which means that a solar or geophysical message is being transmitted. This is followed by the coded information. The coding permits three types of information at each broadcast—each in the form of a group of three letters repeated three times in slow International Morse Code.

The first set concerns either the *forecast* of a solar or geophysical event, or the *observation* of a stratospheric warming (STRATWARM), or both when appropriate. Letters that may occur in the first set and their meanings are as follows:¹¹

- EEE (.) No forecast (or STRATWARM observation) statement
- III (. .) FLARES expected
- SSS (. . .) PROTON FLARE expected
- TTT (—) MAGSTORM expected
- UUU (. . —) FLARES and MAGSTORM expected

VVV (— — —) PROTON FLARE and MAGSTORM expected
 HHH (....) STRATWARM observed
 DDD (— ...) STRATWARM observed and FLARES expected
 BBB (— ...) STRATWARM observed and PROTON FLARE expected
 MMM (— —) STRATWARM observed and MAGSTORM expected

The second and third sets of letters pertain to the approximate time of occurrence of an *observed* solar or geophysical event. The coding for the beginning time and type of event is shown in the table given below:

| | Day before that of issue (hours UT) | | | | Day of issue | In progress | Nil |
|---|--|--------------|----------------|--------------|-----------------|----------------|------------|
| | 00-06 | 06-12 | 12-18 | 18-24 | 00-04 | | |
| Second letter set PROTON EVENT | MMM (— —) | TTT (—) | HHH (...) | SSS (...) | III (.) | GGG (— —) | EEE (.) |
| Third letter set GEOMAG- NETIC STORM | UUU (. —) | AAA (. —) | BBB (— ...) | DDD (— .) | NNN (—) | PPP (. — —) | EEE (.) |

For example, the following message (in International Morse Code)

GEO SSS EEE DDD

signifies:

GEO = Solar geophysical message
 SSS = PROTON FLARE expected
 EEE = No PROTON EVENT between 0000 UT yesterday and 0400 UT today
 DDD = GEOMAGNETIC STORM began between 1800-2400 UT yesterday

NBS STANDARD FREQUENCY AND TIME SERVICES

The 1968 Edition of National Bureau of Standards Special Publication 236, *NBS Standard Frequency and Time Services*¹² (14 pages, 15 cents), gives an up-dated detailed description of the eight services provided by NBS radio stations WWV, WWVH, WWVB, and WWVL: standard radiofrequencies, standard audiofrequencies, standard musical pitch, standard time intervals, time signals, UT2 corrections, radio propagation forecasts, and geophysical alerts.

Improvements in broadcasting techniques and in accuracies of time measurements are reflected in changes that are made from time to time in the broadcast schedules and content, making it necessary to revise Special Publication 236 annually. The present edition describes the services as of January 1, 1968.

Changes in the 1968 edition are traceable primarily to two major developments. In October of 1967 the International Committee of Weights and Measures, at its thir-

teenth General Conference, designated an atomic frequency standard as the international standard of time. And on January 1, 1968, a new coding system was instituted for broadcasting GEOALERT's, superseding previous codes. The new system makes possible the dissemination of larger quantities of information resulting from improved techniques in the observation and prediction of geophysical events.

STANDARD FREQUENCY AND TIME BROADCASTS

WWV—2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz

WWVH—2.5, 5.0, 10.0, and 15.0 MHz

WWVB—60 kHz

Radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast signals that are kept in close agreement with the UT2 scale by making step adjustments of 100 ms as necessary. Each pulse indicates that the earth has rotated approximately 15 arcseconds about its axis since the previous one. The pulses occur at intervals that are longer than one second by 300 parts in 10¹⁰ due to an offset in carrier frequency coordinated by the Bureau International de l'Heure (BIH), Paris, France. Adjustments are made at 0000 UT on the first day of a month. *There will be no adjustment made on December 1, 1968.*

Radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses derived from the NBS Time Standard (NBS-III) with no offset. Step adjustments of 200 ms are made at 0000 UT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be no adjustment made on December 1, 1968.*

¹ Calibration and Test Services of the National Bureau of Standards, NBS Spec. Publ. 250 (May 1968). Available for \$1.75 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

² Calibration of microwave noise sources, NBS Tech. News Bull. 47, 31-34 (Feb. 1963).

³ Microwave noise sources: Calibration available in WR 62 waveguide, NBS Tech. News Bull. 49, 136 (Aug. 1965).

⁴ Noise Temperature (at a Port): The temperature of a passive system having an available noise power per unit bandwidth equal to that of the actual Port, at a specified frequency. IRE Standards on Electron Tubes: Definitions of Terms, 1957 (57 IRE 7.52), Proc. IRE, 45, 983-1010 (July 1957).

⁵ The name of the unit of thermodynamic temperature was changed from degree Kelvin (symbol: °K) to kelvin (symbol: K) by action of the 13th General Conference on Weights and Measures, Paris, Oct. 1967. See NBS Tech. News Bull. 52, 12 (Jan. 1968).

⁶ Allred, C. M., A precision noise spectral density comparator, J. Res. NBS 66C, 323-330 (Oct.-Dec. 1962).

⁷ Patent No. 3,192,372, issued to C. M. Allred.

⁸ Arthur, M. G., Allred, C. M., and Cannon, M. K., A precision noise-power comparator, IEEE Trans. Instr. Meas. IM-13, 301-305 (Dec. 1964).

⁹ International Ursigram and World Days Service, Circular Letter RWC-104, July 12, 1968 (A copy may be obtained from J. V. Lincoln, Deputy Secretary, IUWDS, ESSA, R43.7, Boulder, Colo. 80302).

¹⁰ GEOALERT broadcast code changed, NBS Tech. News Bull. 52, No. 2, 31 (Feb. 1968).

¹¹ The International Morse code symbols in parentheses are given for single letters only; i.e., E is one dot, EEE would be three dots separated by the appropriate intervals.

¹² Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

CRITICAL TWO-PHASE FLOW INVESTIGATED

Data Obtained for Cryogenic Design

In recent years there has been a tremendous expansion in the use of cryogenic liquids for aerospace and commercial applications. This has necessitated the high-velocity transfer of large quantities of low-temperature fluids, which, in turn, has created a demand for basic data on fluid flow phenomena. Such data are needed by cryogenic engineers for the optimum design of transfer lines and other components of cryogenic systems for steel manufacturing, aerospace engineering, natural-gas liquefaction, and the frozen-food industry. These data are particularly needed for the design of transfer systems for two-phase flow, where both liquid and vapor phases exist simultaneously, and where the mass rate of flow is often limited by choking in a restriction (critical flow) such as a valve or at the exit of the system.

To develop a useful general solution to the two-phase critical-flow problem, R. V. Smith of the NBS Institute for Basic Standards recently conducted an experimental and analytical investigation¹ of this type of flow in a venturi.* Using a stepwise integration method, he developed a mathematical model to represent the mechanisms of heat, mass, and momentum transfer between the phases. With this model, in which the equations for each phase may be used separately, the behavior of the flow from subcritical to critical may be evalu-

ated for a reasonably accurate prediction of the pressure profile.

The importance of critical two-phase flow has led to a fairly extensive literature on the subject and to the development of a variety of analytical models for calculation of the appropriate flow rates. However, while these prediction methods have been relatively successful for the evaluation of critical-mass velocity, they have been less successful than the NBS method in predicting the pressure profile for the flow approaching the critical condition, and in producing a basic understanding of the phenomenon.

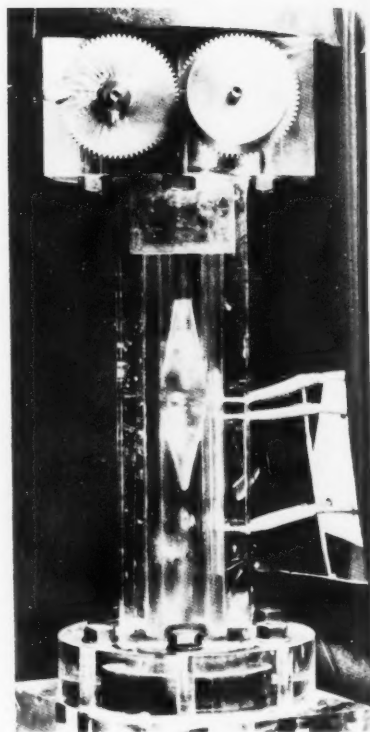
In the Bureau's experimental investigation of critical two-phase flow, an air-water system was selected because of its simplicity and ease of control. At first all-gas flow was used; then, as increasing quantities of liquid were added, the changes in the system parameters were determined and analyzed.

The venturi used in the experimental apparatus consisted of a core, in the form of two base-to-base cones, which was positioned coaxially in a straight, transparent acrylic resin tube. This arrangement allowed visual as well as high-speed photographic observation of the flow.

The annular gap between the nose-piece of the venturi core and the tube had the form of a converging-diverging venturi section with critical and near-critical conditions at the throat. By moving the nosepiece of the venturi core axially, with respect to a fixed pressure tapping on the wall of the straight tube in which it was mounted, it was possible to obtain precise pressure profiles in the difficult region near the critical point.

A significant result from this study was the finding that comparisons between pressure profiles determined

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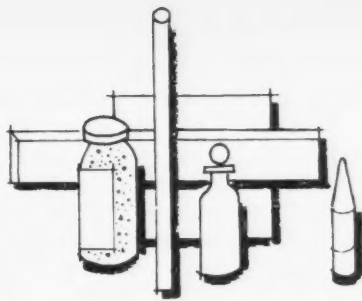
The venturi core (center, inside tube) was designed so that it could be moved up or down to make pressure measurements (by taps attached at right) at varying distances from the constant-area throat.

Close-up view of two-phase critical flow in annular venturi. The band visible on the venturi core marks the constant-area throat. Above the band, the air-water flow is converging to this area while below the band the flow is diverging.



*A venturi is a device that provides a region of converging flow followed, on the downstream side, by a region of immediately diverging flow. For a gas, when critical flow exists at the point of minimum cross section, there will be a subsonic flow upstream of that point and supersonic flow downstream of that point. Pressure reductions downstream of the point of critical flow will no longer increase the flow rate.

STANDARD REFERENCE MATERIALS



Standard Reference Materials are well-characterized materials disseminated by NBS to be used in calibrating and evaluating measuring instruments, methods, and systems or to produce scientific data that can be referred readily to a common base. These materials are certified for chemical composition or for a particular physical or chemical property. They are used on-site in science and industry for calibrating the instruments and methods used for production and quality control of raw materials, chemicals, metals, ceramics, fuels, and radioactive nuclides in manufacturing processes and in research. This column regularly reports on the issuance of new and renewal Standard Reference Materials and on latest developments in the Standard Reference Materials Program.

The NBS Office of Standard Reference Materials has recently added three new biomedical standards, two new high-purity gold standards, and two new gold-coating thickness standards to the more than 650 standard reference materials¹ it disseminates to science and industry for use in calibrating equipment and for controlling product quality.

Biomedical Standards

The three new biomedical standards have been prepared for use in calibrating and standardizing procedures and apparatus employed in clinical chemistry.

The standards are: SRM 912, Urea; SRM 913, Uric Acid, both of which are certified at 99.7 ± 0.1 percent purity; and SRM 914, Creatinine, which is certified at 99.8 ± 0.1 percent purity.

Chromatographic and spectrometric techniques were used to determine the homogeneity of the lots from which the new standards were prepared. These techniques also showed the materials to be free of measurable organic impurities except for a small amount (less than 0.07 percent) of biuret in the urea. No organic impurities could be detected in the uric acid even after the application of techniques that should concentrate the impurities.

Spectrometric analysis of the ashes of each of the standards indicated only minor proportions of biologically undesirable metallic elements. Analysis of the bulk materials by neutron activation substantiated these results.

In addition, the purities of the urea and creatinine were determined by phase solubility analysis and the purity of the urea was confirmed by differential scanning calorimetry. The purity of the creatinine also was evaluated by setting limits on amounts of possible impurities that would

go undetected by the chromatographic and spectrometric techniques used.

The new Standard Reference Materials are sold in units of 25 grams for the urea and 10 grams each for the uric acid and creatinine. They may be purchased² at the following prices per unit: SRM 912, \$31; SRM 913, \$25; and SRM 914, \$31.

High-Purity Gold Standards

A high-purity gold, intended for use in research and analytical work related to the many scientific and industrial applications of gold, has been prepared and is available as a standard reference material in two different physical forms.

SRM 685-W, High Purity Gold in Wire Form, was prepared for use in calibrating spark source mass spectrometers and for determining the limits to which these instruments can detect impurities in gold. It may also be used for a "known" high-purity electrode material on which "unknown" samples of gold or other materials may be placed for analysis.

SRM 685-R, High Purity Gold in Rod Form, was prepared for use as a special research material to further both chemical and physical methods of characterization.

The material for both standards was prepared by Cominco American, Inc., from a special lot of highly purified gold, which was homogenized and processed into the wire and rod forms. A Certificate of Analysis supplied with the standards gives the state-of-the-art information on the chemical composition, including values for copper, indium, iron, oxygen, and silver. In addition, the estimated upper limits of concentration are provided for 21 other elements whose presence was detected by spark source mass spectrometry.

Extensive homogeneity testing was performed at the NBS laboratories in Gaithersburg, Md., and in Boulder, Colo.; the homogeneity of the material was found to be satisfactory within the limits of precision of the analytical methods used. The testing and analysis of the gold were performed using combinations of the following methods: neutron activation, polarography, spectrophotometry, spark source mass spectrometry-isotopic dilution, and vacuum fusion. Additionally, optical emission spectrochemical analysis and electrical measurements for residual resistivity ratios were used in the homogeneity tests.

The need for high-purity gold standard reference materials, particularly for application to spark source mass

continued

REFERENCE MATERIALS *continued*

spectrometry, was firmly established in late 1966 as a result of a questionnaire sent to 202 individuals working in this field. The consensus was that gold was the most ideally suited high-purity standard for spark source mass spectrometry, which has been used increasingly over the last few years for high-purity analysis. This instrument has the capability of determining most of the elements in the periodic table to the parts-per-billion range. It is perhaps the best screening tool for trace characterization below the parts-per-million level. It is readily apparent, however, that a great deal more standardization and calibration are required before the instrument can reach its full potential for providing reliable and accurate quantitative results. The practical capabilities of the instrument and the spark techniques have been restricted by lack of standards that all workers could use as a common base.

The gold wire, SRM 685-W, is expected to serve as one essential bench mark for the mass spectrometric method. Gold contains the minimum of interfering lines, it can be obtained in a relatively high state of purity, and it is exceptionally stable during storage in normal clean environments for long periods of time.

The new high-purity gold standards each cost \$50 per unit.² SRM 685-W is in wire form 1.44 mm (0.055 in) in diameter and 10.2 cm (4 in) long; SRM 685-R is in rod

form 5.9 mm (0.23 in) in diameter and 2.5 cm (1 in) long.

Gold Coating Thickness Standards

Two gold coating thickness standards on nickel substrates, SRM's 1375 and 1378, have been issued to supplement two earlier coating standards, SRM's 1376 and 1377, which became available in June 1968.³ The four standards, SRM's 1375, 1376, 1377, and 1378, have nominal coating weights of 1.5, 3, 6, and 17 mg/cm², respectively, and are 15 mm square. They may be purchased separately for \$43 each or in combinations of two (\$68) or four (\$118) different standards.²

The combinations should be ordered by the SRM numbers shown below:

| SRM | Combinations |
|-----------|--|
| 1384----- | One each of SRM's 1375 and 1376 |
| 1385----- | One each of SRM's 1376 and 1377 |
| 1386----- | One each of SRM's 1377 and 1378 |
| 1399----- | One each of SRM's 1375, 1376, 1377, and 1378 |

¹ For a complete list of Standard Reference Materials available from NBS, see Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards, NBS Misc. Publ. 260 (1968 ed.), for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 45 cents. Quarterly insert sheets which update Misc. Publ. 260 are supplied to users on request.

² These standards may be purchased for the price indicated from the Office of Standard Reference Materials, Rm. B308, Chemistry Bldg., National Bureau of Standards, Washington, D.C. 20234.

³ See Standard Reference Materials, NBS Tech. News Bull. 52, No. 8, 186 (Aug. 1968).

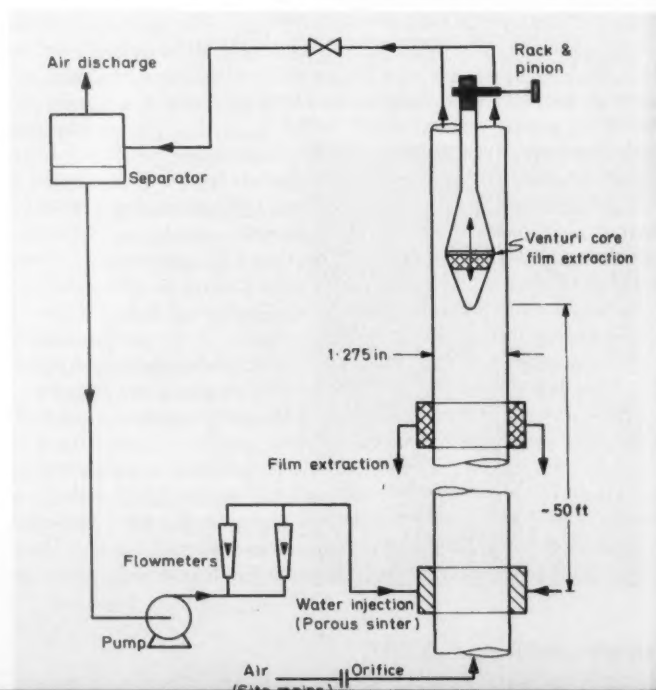
TWO-PHASE FLOW *continued*

experimentally and analytically by the stepwise integration method are in good agreement. This indicates that the analytical program expresses a generally correct functional relationship between the primary flow variables; that is, the mass rates of gas and liquid flow, the pressure, and the geometry of the flow section.

This analytical procedure has two advantages over those previously proposed. First, the model may be used to predict the flow behavior upstream of the critical condition as well as at the point of critical flow. Second, the method provides a simple physical explanation for critical two-phase flow by introducing the criterion that the gas phase must be in critical flow if the mixture is in critical flow.

¹ Smith, R. V., Two-Phase, Two-Component Critical Flow in a Venturi, doctoral thesis (June 1968), available from The Cryogenic Data Center, NBS, Boulder, Colo. 80302.

Flow circuit of the air-water loop used in the study of critical two-phase flow in a venturi. The film extractor is used to determine the amount of film flow, which is subtracted from the total flow for an accurate determination of critical flow.



CONFERENCE *Briefs*

SYMPOSIUM ON ION-SELECTIVE ELECTRODES

The present and future capabilities of ion-selective electrodes will be discussed at a Symposium on Ion-Selective Electrodes at the National Bureau of Standards (Gaithersburg, Md.), January 30-31, 1969. Sponsored by NBS, the Symposium will consist of ten invited papers and will review the theory, characteristics, methodology, and applications of these electrochemical sensors.

During the past several years, continued developments in ion-selective electrodes have produced a renewed interest in classical potentiometric techniques. Such techniques are widely used in biomedical research, oceanographic research, quality and process control, and routine laboratory determinations. As a result, new information on these electrodes has grown rapidly. It is the purpose of this meeting, therefore, to collate and to record—for the first time and in one place—the growing accumulation of data.

The Symposium will attempt to provide a broad, perceptive view of ion-selective electrodes by surveying the state of the art for this subject in a wide range of scientific disciplines. Topics to be presented are: Theory of membrane electrode potentials; solid-state, liquid ion-exchange and impregnated silicone rubber membrane electrodes; thermodynamic studies; activity standards; biomedical research; clinical and pharmaceutical applications; analytical studies; industrial analysis and control; and miscellaneous analytical applications.

A round-table discussion and question period at the close of each session will provide a forum for the interdisciplinary exchange of information on novel applications, techniques, and experimental difficulties. The papers and discussions are expected to be published by NBS as a state-of-the-art monograph.

Further program and registration information can be obtained from the Symposium Chairman, Richard A.

Durst, Room B326, Chemistry Building, National Bureau of Standards, Washington, D.C. 20234, Tel. 301-921-2860.

SCHEDULED NBS-SPONSORED CONFERENCES

Each year NBS sponsors a number of conferences covering a broad range of topics in science and technology. The conferences listed below are either sponsored or cosponsored by NBS and will be held at the Bureau's Gaithersburg, Md., facility unless otherwise indicated. These conferences are open to all interested persons unless specifically noted. For further information, address the person indicated below in care of Special Activities Section, Room A600, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

Symposium on Natural Products. Dec. 12. Cosponsor: Chemical Society of Washington. Contact: G. Brauer (NBS Polymers Division).

Symposium on Ion-Selective Electrodes. Jan. 30-31. Contact: R. A. Durst (NBS Analytical Chemistry Division).

Symposium on Meteorological Observations and Instrumentation. Feb. 10-14. Sponsor: American Meteorological Society. Contact: R. Cook. To be held at the Washington Hilton, Washington, D.C.

Thermodynamics of Bulk Polymers Symposium. Mar. 10-11. Contact: A. B. Bestul (NBS Polymers Division).

Fundamental Aspects of Dislocation Theory. Apr. 21-25. Contact: J. Simmons (NBS Metallurgy Division).

NBS Measurement Seminars and Workshops 1968-1969. Two- to five-day courses on measurement and calibration problems. Attendance limited. See October *Technical News Bulletin* for detailed information.

LASER *continued*

centration of anisotropic molecules in mixtures of two unassociated liquids.

Other results obtained in the study included the adaptation of a Debye equation, concerning polar molecules, for relating orientation line-width to fluid viscosity. Also, from a study of the orientation spectra of

the Rayleigh lines, the first known measurement was made of the polarizability of carbon tetrachloride in its liquid phase.

This experimental and theoretical study of the Raman and Rayleigh spectra has led to a more meaningful understanding of molecular kinetics in the liquid phase, especially in relation to the relaxation time for mole-

cules. NBS plans to continue the work in an effort to gain more knowledge concerning light-scattering effects in liquids.

¹ McClintock, M., Jennings, D. A., and Mizushima, M., Contribution to the Raman line profile in liquids from molecular reorientation, *Phys. Rev. Letters* **21**, 276 (July 1968).

² Steele, W. A., Proc. Meeting of the Commission on Thermodynamics and Statistical Mechanics (International Union of Pure and Applied Physics, Copenhagen, Denmark, July 1966).

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

Technical News Bulletin, Volume 52, No. 10, October 1968. 30 cents. Annual subscription: Domestic \$3; foreign, \$4. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, \$6; foreign, \$7.25. Single copy, \$1.

Section B. Mathematical Sciences. Issued quarterly. Annual subscription: Domestic, \$2.25; foreign, \$2.75. Single copy, 75 cents.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, \$2.75; foreign, \$3.50. Single copy, 75 cents.

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